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Intracranial Arachnoid Cysts in Adulthood: A Retrospective, Multicenter Magnetic Resonance Imaging-Based Study

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ABSTRACT

AIM: To retrospectively evaluate the cranial magnetic resonance imaging (MRI) features and determine the incidence of intracranial arachnoid cysts (ACs) based on sex, age, location, size, affected side, Galassi type, and their association with hydrocephalus, mega cisterna magna (MCM), bone erosion, and midline brain shift in 15,108 patients during outpatient headache evaluations.

MATERIAL and METHODS: Between 2012 and 2022, cranial MRI scans of 15,108 adult patients aged 20–70 years undergoing outpatient evaluations for headaches were retrospectively reviewed to analyze the features of ACs detected incidentally. Patients who had previously undergone a craniotomy or craniectomy were excluded from the study.

RESULTS: The relationship between the location of AC and hydrocephalus did not show statistically significant differences between the supratentorial and infratentorial subgroups (p=0.557). The relationship between the location of AC and MCM showed statistically significant differences between the two groups (p=0.008). MCMs occur more commonly in supratentorial ACs than in infratentorial ACs.

CONCLUSION: The increased use of MRI in assessing patients with headaches has resulted in an increased detection of ACs. Although managing asymptomatic lesions typically involves periodic follow-ups, symptomatic lesions can sometimes require surgical treatment, such as AC fenestration, cyst aspiration, endoscopic shunt placement, or microneurosurgery.

KEYWORDS: Arachnoid cyst, Mega cysterna magna, Robotic surgery, Cystoperitoneal shunt

ABBREVIATIONS: AC: Arachnoid cyst, **CSF:** Cerebrospinal fluid, **CPA:** Cerebellopontine angle, **CPS:** Cystoperitoneal shunt, **CT:** Computed tomography, **ICP:** Intracranial pressure, **MCM:** Mega cisterna magna, **MRI:** Magnetic resonance imaging, **SD:** Standard deviation

INTRODUCTION

Intracranial arachnoid cysts (ACs) are nonneoplastic cystic malformations arising from the arachnoid membrane and are typically filled with cerebrospinal fluid (CSF). The pathogenesis of ACs remains unclear. However, the separation of the arachnoid membrane permits the abnormal collection of CSF. Assumptions concerning cyst growth include the osmotic gradient (12,24), CSF formation by the cyst wall (9,12), and the slit valve mechanism (11,12). ACs within the

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cranial cavity is predominantly of congenital origin. Secondary cysts are less common and are regularly encountered following intracranial hemorrhage, trauma, or surgery (12,14,22). The prevalence of these cysts in adults is 1.4%, with male predominance (1); however, the prevalence in the pediatric population is 2.6% (2). Symptoms associated with ACs depend on their location and size. Small ACs is often asymptomatic. However, large lesions may produce neurological signs because of elevated intracranial pressure (ICP), CSF obstruction, and compression of the surrounding neurovascular structures (21,26). Headaches frequently constitute the primary symptom of ACs (13). ACs can lead to an enlarged head size, hydrocephalus, cognitive symptoms, seizures, cranial nerve neuropathy, focal neurological deficits, such as hemiparesis, and cerebellar symptoms (1,2,12). ACs can be found in any part of the central nervous system. Around 50-65% of ACs manifest within the middle cranial fossa (1,10,13,21). Other locations include the cerebellopontine angle (CPA), sellar, suprasellar, and quadrigeminal cisterns, retrocerebellar region, and cerebral convexity (1,2,10,21). Cysts situated in the sellar, ambient, and quadrigeminal cisterns or CPA tend to be more symptomatic than others (1,2). One option for managing ACs is surgery; endoscopic fenestration, microsurgical fenestration with craniotomy, and cyst excision with shunt placement (5,19,25). A newer treatment procedure described in this article is cyst fenestration using a robotic surgical system. Surgery is indicated for symptomatic ACs due to compression of surrounding neurovascular structures, increased ICP, and hydrocephalus (3,4). However, these surgeries are associated with potential morbidity. Owing to ongoing advancements in neuroimaging, early identification of ACs has become common in both symptomatic and asymptomatic patients (1,12).

MATERIAL and METHODS

Between 2012 and 2022, the cranial MRI scans of 15,108 adult patients aged 20–70 years who underwent outpatient evaluations were retrospectively reviewed (Ankara University Ethics Committee; Date: 24.03.2024; No: 2024090358). Demographic information of each patient was collected. All images and medical records of each patient were evaluated. The diagnosis of ACs was confirmed by neuroradiologists. The following additional data were collected from the patients: medical reports, clinical evaluation reports, symptoms at the time of presentation, and whether surgery had been performed before the chosen surgical procedure. The radiological characteristics of ACs were assessed. Patients were initially categorized based on the location of the ACs into two groups: supratentorial and infratentorial (Table II). Subsequently, patients in these groups were further classified according to the locations specified in Table III. The radiological changes, progression of symptoms, and subsequent surgical needs of the patients were reviewed using their clinical data. Patients who had undergone a prior craniotomy or craniectomy were excluded from the study. Of the 15,108 patients included, ACs was detected in 505 patients using radiography. The Galassi classification was used to determine the Sylvian ACs (8). The data of 194 patients diagnosed with ACs and clinically followed up with more than one imaging studies were evaluated. Patients with ACs who underwent MRI and were clinically followed up for >6 months were evaluated. Patients diagnosed with ACs and treated surgically were reviewed. Surgical procedures were performed only in patients with large symptomatic ACs. Microsurgical fenestration and cyst excision, cystoperitoneal shunt insertion, endoscopic cyst fenestration, and cyst fenestration via robotic surgery were performed.

Case examples and surgical procedures

The supratentorial ACs were most commonly located in the temporal lobe, followed by the frontal lobe (Figures 1 and 2). Additionally, we identified some ACs at rare locations (Figures 3 and 4).

The most common infratentorial ACs were retrocerebellar ACs (Figure 5), followed by CPA ACs (Figure 6). Additionally, we identified some infratentorial ACs at rare locations (Figure 7).

In this study, patients diagnosed with ACs and surgically treated at our clinic were assessed. Microsurgical fenestration or cyst excision (Figure 8), endoscopic fenestration (Figure 9), cystoperitoneal shunt placement (Figure 10), and robotic cyst fenestration (Figure 11) were the surgical procedures performed.

Statistical Analysis

All statistical analyses were performed using SPSS for Windows (version 22.0). Descriptive variables were expressed as frequencies, percentages, means, SDs, medians, and minimum–maximum. The chi-square test was employed for the analysis of categorical variables, and statistical significance was defined as a p-value below 0.05.

RESULTS

A total of 505 patients, comprising 257 males and 248 females, were included in the study. The mean age of the study population (n=505) was 32.7 years, with an SD of 21.7 years. (Table I). In this study, 351 (69.5%) and 154 (30.4%) ACs was situated in the supratentorial and infratentorial regions,

Table I: Gender Distrubition of Patients

Gender	n (%)
Female	248 (49.1)
Male	257 (50.9)
Total	505 (100.0)

Table II: Distribution of Arachnoid Cysts by Supratentorial and Infratentorial Location

Location of Arachnoid Cysts	n (%)
Supratentorial	352 (69.7)
Infratentorial	153 (30.3)
Total	505 (100.0)

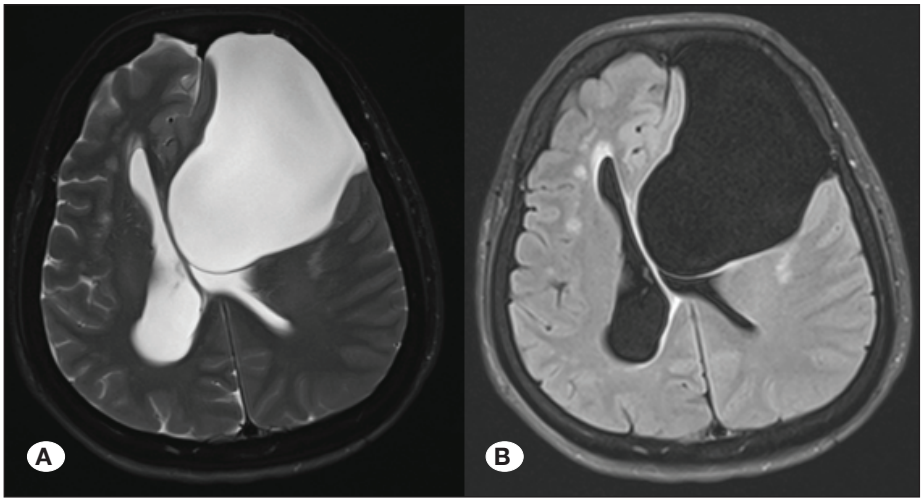

Figure 1: T2-weighted axial MRI **(A)** and T1-weighted axial MRI **(B)** show an AC covering the left frontal lobe with significant ventricular system compression.

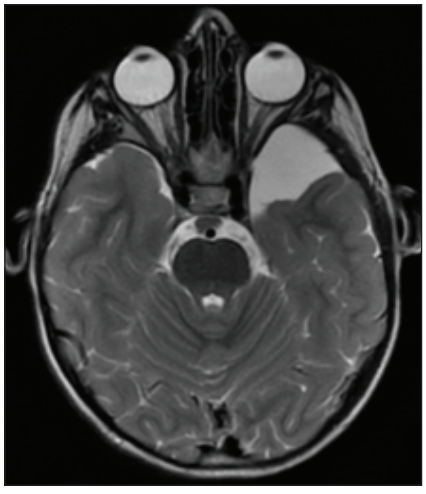

Figure 2: T2-weighted axial MRI showing an AC located in the temporal lobe (Galassi Grade I).

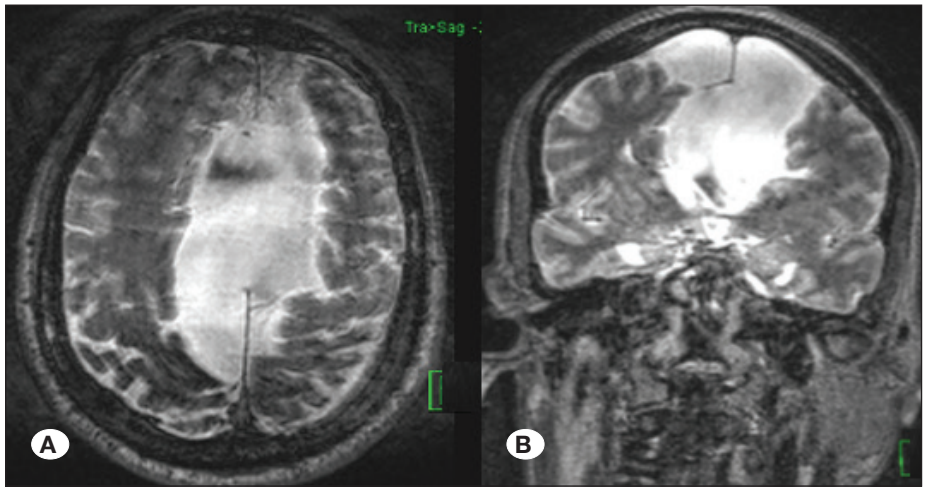

Figure 3: T2-weighted axial MRI scans showing an interhemispheric AC **(A)**. T2-weighted coronal MRI scans showing an enlarged cyst with agenesis of the corpus callosum **(B)**.

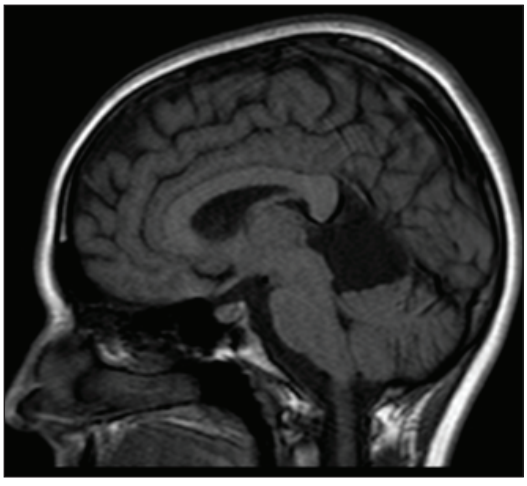

Figure 4: T1-weighted sagittal MRI scan showing a large pineal region AC measuring 3 cm × 2.8 cm × 3.2 cm.

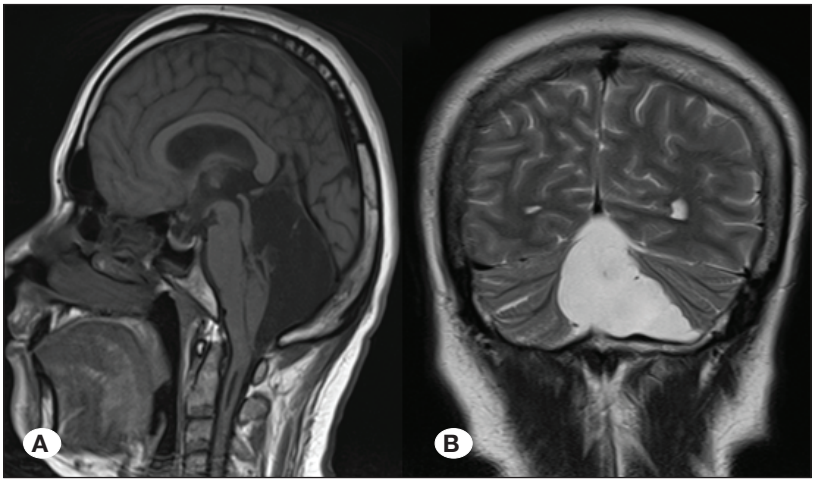

Figure 5: T1-weighted sagittal **(A)**, and T2-weighted coronal **(B)** MRI scans showing retrocerebellar arachnoid cyst.

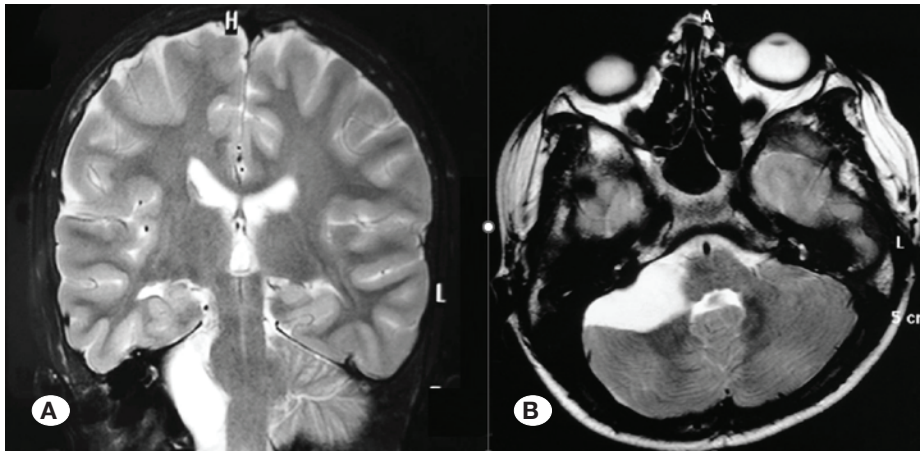

Figure 6: A coronal T2-weighted MRI scan showing AC with brain stem compression **(A)**. Axial T2-weighted MRI scan showing an AC located in the right cerebellopontine angle **(B)**.

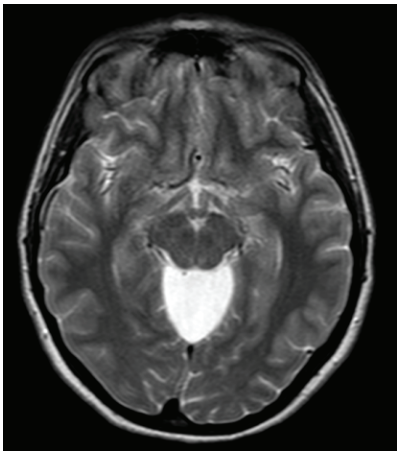

Figure 7: Retromesencephalic localization is a rare occurrence for ACs.

Table III: Location of Arachnoid Cysts

Location		n (%)	MCM
Supratentorial	Bifrontal	1 (0.198)	0
	Bilateral Temporal	1 (0.198)	0
	Interhemispheric	1 (0.198)	0
	Intraparanchymal	1 (0.198)	0
	Left Retroorbital	1 (0.198)	0
	Suprasellar	1 (0.198)	0
	Calvarial	3 (0.594)	0
	Pineal	3 (0.594)	0
	Left Parietal Convexity	6 (1.188)	2
	Parasagittal	11 (2.178)	3
	Right Parietal Convexity	11 (2.178)	5
	Left Frontal	39 (7.723)	6
	Right Frontal	43 (8.515)	8
	Right Temporal	92 (18.218)	11
	Left Temporal	137 (27.129)	14
	Total	351 (69.505)	49
Infratentorial	Tentorial	1 (0.198)	0
	Supracerebellar	1 (0.198)	0
	Quadrigeminal Cystern	1 (0.198)	0
	Left Cerebellopontine Angle	17 (3.366)	0
	Right Cerebellopontine Angle	19 (3.762)	1
	Left Retrocerebellar	50 (9.901)	5
	Right Retrocerebellar	65 (12.871)	3
	Total	154 (30.495)	9
Total		505 (100)	37

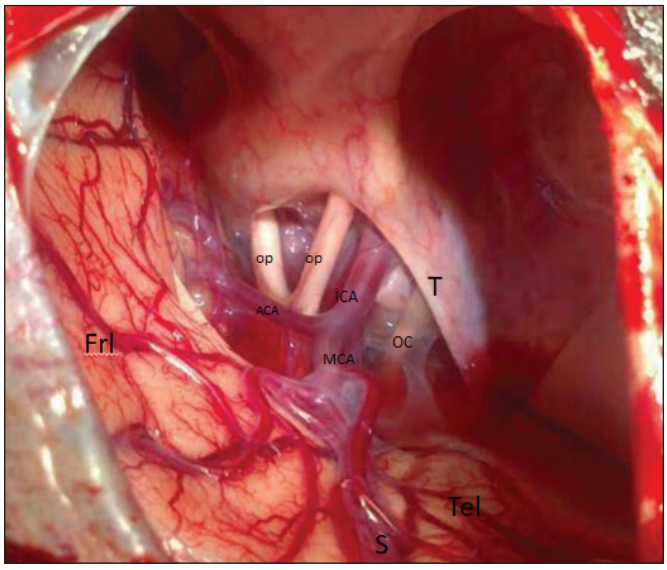

Figure 8: Intraoperative microsurgical views of the right AC. Image after perforation of the outer membrane of the AC wall and microsurgical fenestration to establish communication between the cyst and cisterns. Frontal lobe (FRL), internal carotid artery (ICA), oculomotor nerve (OC), optic nerve (OP), internal carotid artery (ICA), anterior cerebral artery (ACA), middle cerebral artery (MCA), the free edge of the tentorium (T), superficial Sylvian vein (S), and temporal lobe (Tel).

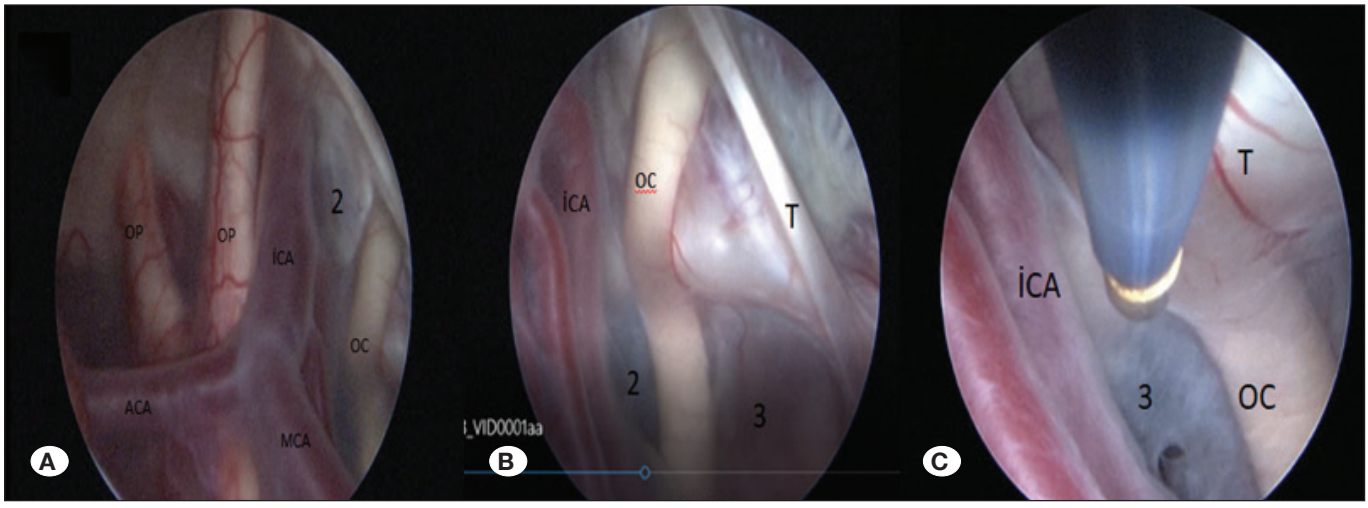

Figure 9: A and **B** intraoperative endoscopic view of a right-sided Galassi III Sylvian AC. Optic nerve (OP), internal carotid artery (ICA), oculomotor nerve (OC), anterior cerebral artery (ACA), middle cerebral artery (MCA), and the free edge of the tentorium (T). The cyst membrane is located at the carotico–oculomotor triangle (2). The cyst membrane is located at the oculomotor–tentorial triangle (3). **C)** The membrane located at the carotico–oculomotor triangle (3) was perforated using a monopolar probe.

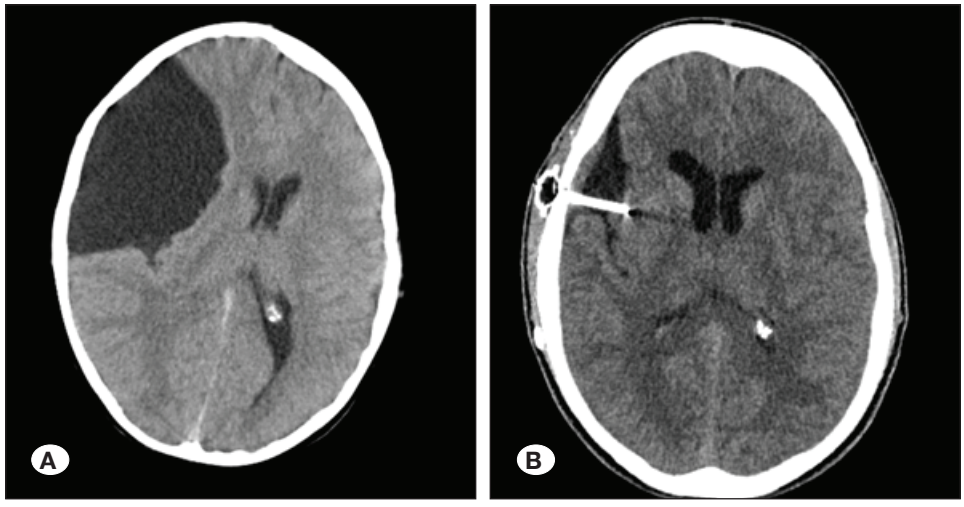

Figure 10: CT scan of a patient with a large right AC (Galassi classification type III) treated with cystoperitoneal shunt **(A)**. Postoperative CT of a patient with reduced cyst size **(B)**.

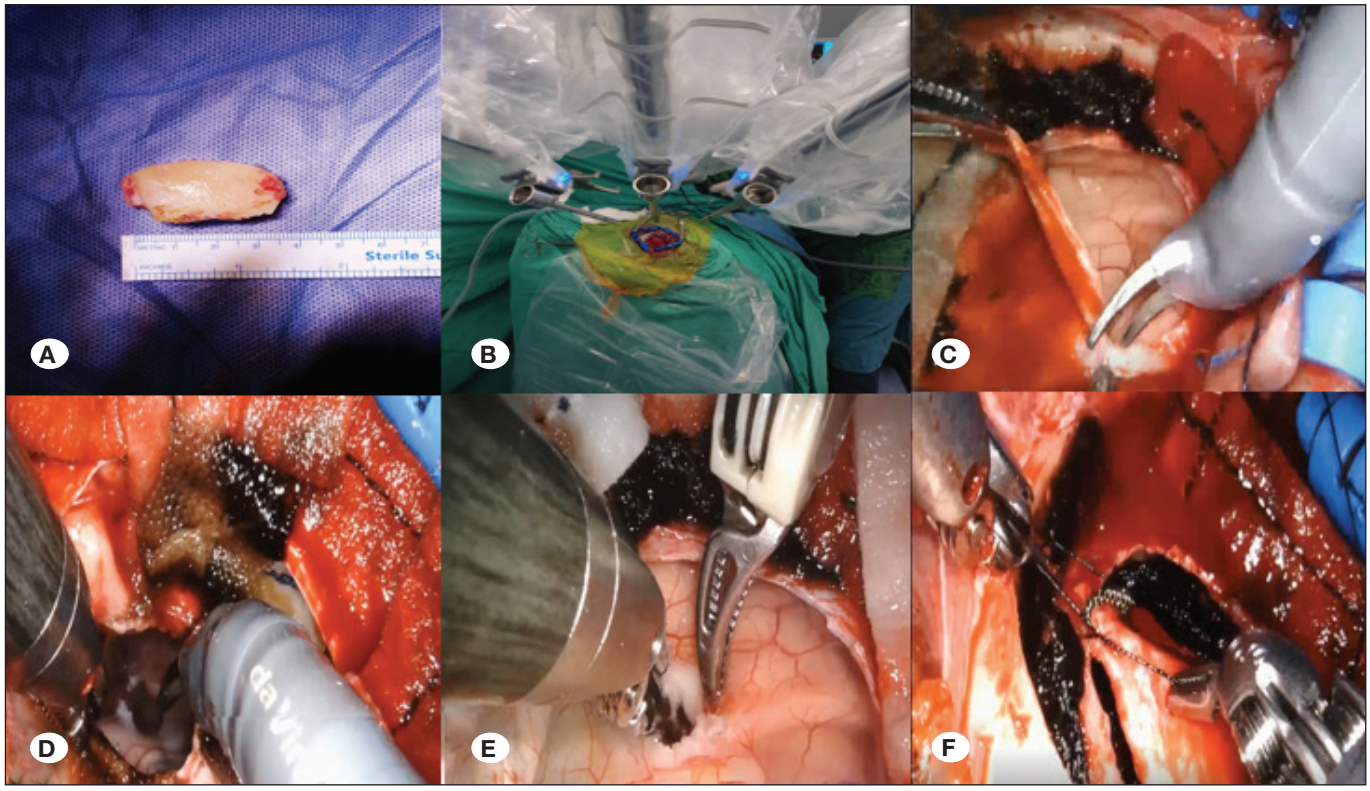

Figure 11: Intraoperative images of the patient who underwent robotic cyst fenestration: craniotomy **(A)**, placement of robotic arms **(B)**, dural opening with robotic scissors **(C)**, cortical incision **(D)**, cyst fenestration **(E)**, dural saturation **(F)**.

respectively (Table II). The supratentorial lesions were most commonly located in the left (n=137; 27.1%) and right (n=92; 18.2%) temporal regions (Table III). Hydrocephalus developed in three (0.7%) patients. A midline shift was observed in seven (1.4%) patients and bony erosion in 27 (5.3%) patients. Twenty-eight (5.5%) patients developed MCM. Among the patients included in the study, 229 had ACs that could be classified according to the Galassi classification system: type I cysts, n=163 (32.3%); type II, n=55 (10.8%); and type III, n=11 (2.2%) (Table IV). In our study, 54 patients were symptomatic. The symptoms are summarized in Table V. The clinical and radiological follow-up of 194 patients showed that the cyst grew in eight patients. Of these eight patients, four developed new progressive symptoms. The cyst regressed in one patient. The growing cysts were located in the temporal region in four of these patients, at the CPA in two, and in the cerebral convexity in two. Four patients underwent surgery because they developed new symptoms. Surgery was performed in 17 patients (3.3%) who presented with progressive neurological symptoms, hydrocephalus development, and midline shift. Among these 17 patients, one underwent robotic-assisted surgery, six underwent endoscopic cyst fenestration, four underwent microsurgical cyst fenestration, three had cyst excision, and three underwent cystoperitoneal shunt placement surgery.

The relationship between cyst location and hydrocephalus did not show statistically significant differences between the supratentorial and infratentorial subgroups (p=0.557). The relationship between AC location and MCM showed statistically significant differences between the groups

Table IV: Distribution of Arachnoid Cysts according to the Galassi Classification

Galassi Classification	n (%)
Grade 1	163 (32.3)
Grade 2	55 (10.8)
Grade 3	11 (2.2)
Total	229 (45.3)

Table V: Characteristics of 54 Patients Who were Symptomatic

Symptoms	Number of Patients
Headache	23
Nausea/vomiting	10
Gait disturbance	6
Cranial nerve palsy	4
Seizures	4
Dizziness	3
Paresis	3
Dysphasia	1
Total	54

(p=0.008). MCMs occur more commonly in supratentorial ACs than in posterior fossa ACs.

DISCUSSION

Advancements in intracranial imaging, ease of access, and increased MRI usage have led to a rise in the diagnosis of ACs (1,6,17). Among the 15,108 adults included in our study, ACs was detected in 505 patients using radiography (3.3%). A large MRI-based study on AC prevalence reported that the prevalence of ACs was 1.4% among 48,417 adult patients (1). Another MRI-based study reported that the prevalence of ACs was 43 (1.7%) in 2,563 military recruits aged 17 years and older. (27). In population-based studies, the prevalence of ACs ranged from 1.1% to 2.3% (12,23,27). In our study, 257 (50.9%) patients were male and 248 (49.1%) patients were female. ACs was more prevalent in the supratentorial region (69.5%) than in the infratentorial region. Supratentorial lesions were frequently observed in the left temporal region (n=137; 27.1%), whereas infratentorial lesions were most commonly found in the retrocerebellar region. Among these lesions, 65 (12.8%) were located on the right side and 50 (9.9%) on the left side. Sex and location characteristics associated with these lesions have been reported in previous studies. Previous studies have indicated that lesions are mostly seen in males (1,2,12,16). Some studies have reported that infratentorial ACs are commonly seen in the retrocerebellar region, which is consistent with the findings of our study (1). In our study, the relationship between AC location and hydrocephalus did not show statistically significant differences between the supratentorial and infratentorial subgroups (p=0.557). Furthermore, the relationship between AC location and MCM showed statistically significant differences between the two groups (p=0.008). This may be attributable to the fact that the incidence of MCMs is higher in supratentorial ACs than in posterior fossa ACs. ACs may induce neurological symptoms because of their size, location, and compression of surrounding neurovascular structures. However, these cysts are often asymptomatic and are incidentally detected (2,20,21). Headache is reportedly the most common symptom (2,7,12). The characteristics of the 54 symptomatic patients in our study are listed in Table V. In our study, the most common symptom was headache (n=23), followed by nausea/vomiting (n=10), and gait disturbances (n=6). Determining the natural history of ACs is important during the follow-up of these patients. It also affects surgical decision-making because of the potential morbidity associated with the surgical treatment of ACs, such as subdural hygroma, subdural hematoma, hemiparesis, cranial nerve palsy, and wound infections. (2,15,16,18) In a study that included 213 ACs in 203 adult patients, the cyst grew in only five patients and only two patients developed new symptoms over the mean follow-up of 3.8 years (1). In our study, the clinical and radiological follow-up of 194 patients revealed that the cyst grew in only eight patients. New progressive symptoms developed in four of these eight patients, whereas the cyst regressed in one patient. The cysts that grew were located in the temporal region in four patients, at the CPA in two, and in the cerebral convexity in two. Surgery was performed on four patients because of the development of new symptoms.

CONCLUSION

The increased use of MRI to assess patients with headaches resulted in increased detection and prevalence of ACs. Managing asymptomatic lesions typically involves periodic follow-up using CT or MRI. However, symptomatic lesions can sometimes require surgical treatment, such as AC fenestration, cyst aspiration, endoscopic shunt placement, or microneurosurgery. Understanding the natural history of these cysts is crucial for treatment, follow-up, and surgical decision-making.

Declarations

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Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

Disclosure: Authors declare no conflict of interest.

AUTHORSHIP CONTRIBUTION

Study conception and design: MZ, OO, SH, UE, HCU, BCA
Data collection: EP, NH, BB, UE, BCA
Analysis and interpretation of results: SH, HAE, OO, EBM
Draft manuscript preparation: OO, BCA, AWT
Critical revision of the article: OO, BCA, EBM, MZ
Other (study supervision, fundings, materials, etc...): EP, UE, HCU
All authors (MZ, OO, BCA, EBM, SH, HAE, AWT, EP, HCU, NH, BB, UE) reviewed the results and approved the final version of the manuscript.

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